Accelerator Physics Experiments for Future Hadron Colliders

EXPERIMENTS IN RHIC (summer 2000 ??):

Beam Growth Studies with Primary and Bent Crystal Collimators

- **Introduction**
- **Previous Experience**
- **Predictions for the Intrabeam Scattering**
- **Bent Crystal Channeling**
- **Experimental Set-Up**

Introduction:

- **Motivation for the experiment:**
  - **Show that *intrabeam scattering* is a dominant effect on the beam life time and on the emittance growth in RHIC $_{197}Au^{79+}$ (important also in the future LARGE Hadron colliders).**
  - **Experimentally find out the exact scale of the problem. Why?**
    - Find the optimum mode for operation!
    - Plan a correct way for the luminosity upgrade - RD projects - what kind?
  - **Connect the experiment with luminosity optimization and Background reduction.**
  - **Use the impact parameter measurements to show the way of beam growth:**
    - First by using the Primary Collimator jaws
    - Second with the CRYSTAL collimation.

Previous Experience:

- **Major "rules":**
  - **Measure a signal downstream of the collimation point without reducing the luminosity**
  - **Fit a response curve to the predicted beam growth (Intrabeam scattering?, Diffusion?)**
- **SPS measurements (LHC note 117):**
  - **Measurements of the transverse difusion speed and the impact parameter-b**
- **Difusion and 778 experiments in the Tevatron**
- **HERA measurements (Bruning et al.)**

Intra Beam Scattering Predictions:

- **INTRA-BEAM multiple Coulomb scattering has cross section:**
  - $\sigma \quad Z^4/A^2$
- **Particles in the bunch exchange longitudinal and transverse momenta by Coulomb scattering**
- **D.C background, beam halo, or trapped particles in the empty buckets, could be created by the escaped particles from the RF bucket (initial bucket area of ~0.3 eVs/u -> ~1.3 eVs/u).**
- **COMPARISONS BETWEEN EXPERIMENTAL STUDIES with THEORY show a factor of two over-estimate by theory.**
- **Beam Growth at $\gamma >> \gamma_t$:**
  - $1/\sigma_x \, d\sigma_x/dt = Z^4 N C_o/(A^2 \varepsilon_x \varepsilon_y S \gamma_t) \, d/n_c$
  - $\tau^{-1} \sim Z^4 N /(A^2 \varepsilon_x \varepsilon_y S)$

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Measurement of the impact parameter *b*:

- **Measurements of the impact parameter *b* by using the edge of the primary collimator or:**
- **Using a bent Si crystal (L=5 mm) (Valery Biryukov Phys. Rev. E 52 (1995) 2045). One looks at the efficiency *F* dependence on *t* (thickness of the septum x’L):**
  - **Accuracy δ*b* = δx’ L = 1 μrad 5 mm = 5 nm! If we plot *F*(x’) - *F*(-x’) as a function of t beam distribution over the impact parameter b at crystal (BPM resolution 0.1 mm).**
  - **θ = 0, t = x’L (x’>0), t = x’L (x’<0)**

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Why Bent Crystal Collimation?

- **The Lindhard Critical angle significantly larger (8.9 times - $79^{1/2}$) :**
  - **$\psi_c=2[Z_1Z_2 e^2/d\, p\, \upsilon]^{1/2}$, where *d* - is the crystal lattice parameter, p - momentum, υ is the speed.**
- **Shorter Crystal (5 mm instead of 4 cm) improves efficiency and reduces the nuclear scattering beam loss**
- **Smaller bending angle (0.5 mrad) reduces angle problems (4-5 mrad previously)**

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